

**EFFECTS OF CULTIVAR AND AGROBOTANICAL STORAGE  
TREATMENT ON ORGANOLEPTIC QUALITY OF YAM  
(*Dioscorea rotundata*)**

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## ABSTRACT

There is current interest in the search and use of agrobotanicals in preference to conventional chemicals in agriculture as plant protectants hence the need to investigate the potential effects of some of the agrobotanicals on yam food after storage. This study was, therefore, conducted to assess the effects of yam cultivar and agrobotanical extracts on the organoleptic quality and acceptability of two yam based food forms: boiled yam and pounded yam. Tubers of four yam cultivars (Nwaopoko, Danacha, Ezakwukpolo and Pepa) were treated with aqueous leaf extracts of Neem (*Azadiracta indica*), Scent leaf (*Occimum gratissimum*), pod extracts of 'Uda' (*Xylopiya aethiopica*), root extracts of Ginger (*Zingiber officinale*) and a synthetic phytohormone (Gibberellic acid) and stored for six months. Thereafter, two food forms (boiled yam and pounded yam) were prepared from the stored yam tubers and a nine-member panel of judges enlisted to perform sensory quality assessment on them. The attributes scored with respect to boiled yam were colour, taste, texture, mealiness and general acceptability while pounded yam was assessed for its aroma, texture, colour and general acceptability. No significant differences were found among the sensory attributes due to the agrobotanical treatments rather, differences were due to yam cultivars. The results obtained and confirmed by the scatter plots and multiple linear regression showed that texture and taste contributed much to the general acceptability of boiled yam while aroma and consistency were the major qualities of pounded yam. Consistency of pounded yam was best with Nwaopoko and Danacha cultivars but significantly less so with other cultivars with or without agrobotanical treatment. The agrobotanical treatments did not affect the culinary quality of the stored yam tubers as no evidence of such treatment was noticed in the prepared yam foods. This result suggests that the constituent active ingredients imparted on the tubers during storage by the plant extracts were either water-soluble and heat labile or that their shelf lives were less than six months of the storage period and therefore had no effects on the quality attributes of food yams

**Key words:** Yam cultivar, Agrobotanicals, Organoleptic quality

## INTRODUCTION

Yam contributes significantly to the diet of many people in the tropics and sub-tropics of Africa, Asia and the Caribbean as a major source of carbohydrate (about 200 dietary calories daily and protein (about 12-14% on a dry matter basis) [1]. Yam broadens the food base and brings food security to 300 million people in the low-income food-deficit countries worldwide [2].

The nutritional value of yam varies greatly between different species and amongst varieties of the same species. Variations are also subject to such other factors, as cultivation methods, climatic and soil characteristics, age of maturity reached by the tuber at harvest, length of storage and the processing techniques [3]. Yam is processed into various food forms, which include pounded yam ( from *D. rotundata* and sometimes from *D. cayenensis* ), boiled yam, roasted yam, or grilled yam, yam balls, mashed yam, yam chips and flakes [4]. Yams may also be prepared for food simply by frying slices usually in palm oil, either with or without preliminary boiling to soften the tissue. Bell and Favier [5] after analyzing various meals made from yam in Cameroon reported that one of the most nutritious ways of preparing yam is to fry in palm oil because boiling reduces its amino acid contents. Yam roasting has moved from farmers' field to the urban centers and therefore demands year round availability of yam tubers for fast foods.

Unfortunately, weight loss during storage through respiration, pests and diseases constitute major problems of yam growers and dealers in West Africa. However, many small operations have been found capable of controlling disease chemically by dips and fumigations [6]. It has been reported that species and cultivar differences were observed in response of yam to chemical treatments [7]. Gibberellic acid has also been reported to suppress sprouting while thiabendazole and deltamethine reduced insect pests of yam in storage [8]. These chemicals are imported and therefore expensive and may not even be available to rural farmers and yam dealers.

There has been some current interest in the search and use of agrobotanicals in preference to conventional chemicals in agriculture as plant protectants. Treatment of yam tubers with extracts of *Azadiractha indica*, *Ocimum gratissimum* and *Xylopia aethiopica* agrobotanicals reduced post-harvest losses of yam in storage [9]. According to this finding, these agrobotanicals suppressed sprouting, reduced weight loss and maintained visual quality of yam after six months of storage compared with the untreated tubers. The use of plant materials or extracts as protectants for storage of farm products such as yam would be desirable due to the availability and cheapness especially in the rural areas among the major producers. However, the answer to the question 'what will be the effects of these plant materials on human food?' formed the basis for this study. Sensory analysis, a multi-disciplinary science that uses human panelists and their senses of sight, smell, taste, touch and hearing measures the sensory characteristics and acceptability of food products [10, 11]

The organoleptic quality of yam-based foods is a major criterion for selection of yam cultivars for food yams by dealers and consumers [12]. However, the potential effects of agrobotanicals as protectants for stored yam tubers are yet to be established by empirical research hence the objective of this study was to determine the effects of yam cultivar (*Dioscorea rotundata*) and agrobotanical extracts on the organoleptic quality and acceptability of two yam-based food forms – boiled yam and pounded yam.

## MATERIALS AND METHODS

This study was carried out at the Department of Home Science, Nutrition and Dietetics University of Nigeria, Nsukka. The yam (*Dioscorea rotundata*) tubers used for the study were obtained from the collections of the storage trials at the National Root Crops Research Institute, Umudike, Nigeria. The yam cultivars – Nwaopoko, Danacha, Ezakwukpolo and Pepa were screened in storage experiment with gibberellic acid (GA<sub>3</sub>) *Azadiractha indica*, *Ocimum gratissimum*, *Xylopi aethiopica*, *Zingiber officinale* agrobotanicals and control (no treatment). Arrangement for the use of the stored yams was made in advance and at the end of six months storage, clean tubers were selected from each cultivar and labeled according to treatment in storage. The tubers were then taken to the Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, where kitchen equipment and utensils are available for yam food preparation.

### Boiled yam food preparation

One tuber of each cultivar was peeled and cut into uniform slices of 10-15 g. Only the middle part of the tuber was used to avoid varied textures of the head and tail or coloration caused by chemical substances in the head region of yam tubers. A sample of the cut pieces of about 100-120 g of each cultivar was wrapped in a transparent polythene bag and tagged with a 3-digit random number. Five aluminium pots, each containing one liter of water were placed on five burning kerosene stoves of equal sizes and capacities. The stoves were lit 4-5 minutes ahead to ensure uniform and steady heat supply to the pots. The cut yams were put in the pots when the water began boiling. Cooking lasted for 20 minutes when the yams were considered done. Doneness was determined by sensing the aroma followed by punching the pieces with a hand fork. The aroma and adherence of particles of yam on the fork were evidence of doneness. After cooking the samples were kept in labeled sample dishes and kept warm until they were ready to be served for sensory analysis. The dishes were of the same colour background in order not to mask the colour of the samples.

### Pounded yam

Preparation of the pounded yam was similar to the boiled yam except that the boiled tuber pieces were pounded in wooden mortar with pestle. Pounding time was the same for the five cultivars (approximately 10 minutes). The average score of the pounded yam was taken as quality attribute.

### **Taste panel**

A nine-member taste panel made up of graduate students and lecturers in the Department of Home Science, Nutrition and Dietetics, University of Nigeria, were trained to conduct the sensory analysis. A preliminary test which served as training class for members of the panel was conducted a day before the main evaluation. The purpose was to familiarize members with both hedonic and descriptor scales. To keep the interest and morale of the panelists for the main evaluation, they were served pounded yam with delicious soup after the preliminary test to show appreciation for their service as well as a warm invitation for the main evaluation. Every member was provided with questionnaire for both objective and subjective sensory evaluation. The objective questionnaire enables each panelist to describe the products while the subjective questionnaire requests them to give information on the degree of like or dislike of the products. This was done on a scale of 1 to 9 where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely.

Each panelist was provided with a cup of water to rinse his or her mouth before tasting the next sample to avoid carrying residual taste of the previous sample to the next one. Boiled yam was evaluated by the panelist for its colour, taste, texture, mealiness and general acceptability. Pounded yam was evaluated for its consistency, aroma, texture, colour and general acceptability. The experiment was repeated with pounded yam 3 hours after the first evaluation. Data were collected using a hedonic scale, which is an ordered classification for subjective quality evaluation on a scale of 1-2, 1-3, 1-4, or 1-9 for each attribute measured [13].

### **Data analysis**

All data collected were taken to the International Institute of Tropical Agriculture (IITA), Ibadan for statistical analysis. The data were analyzed using the Statistical Analysis System (SAS) software package [14]. Analysis of variance was done and means separation was by standard error of difference (s. e. d.). Regression analysis was performed to determine the contribution of each attribute to general acceptability of the food forms. The relationship between the quality attributes of the yam foods and general acceptability to consumers was confirmed with scatter plots.

## **RESULTS**

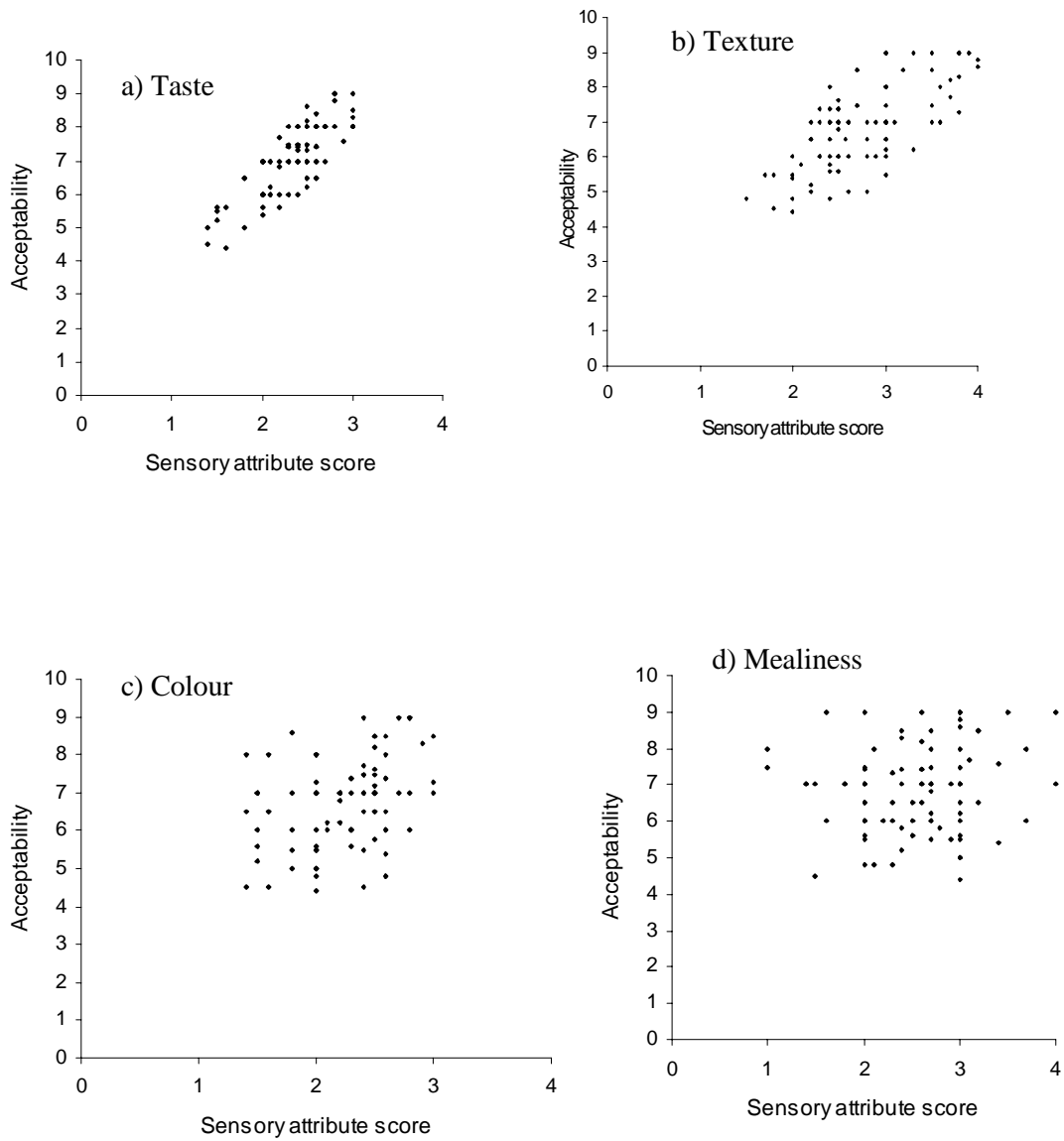
The colours of the boiled yam varied between the scores for cream (2) and yellowish (3) but the scores were closer to cream than yellowish (Table 1). Non-statistically significant differences were observed among the cultivars in their colour attributes. Texture attributes varied significantly ( $p = 0.05$ ) with cultivar. Amula and Pepa cultivars were soft textured while others were slightly hard. Similarly, Amula and Pepa were fairly mealy in the mouth while others ranged from slightly mealy to mealy. Differences in taste attributes of the cultivars were statistically non-significant and varied between slightly sweet and sweet but closer to slightly sweet.

The application of agrobotanical extracts and gibberellic acid (GA<sub>3</sub>) during storage did not significantly affect the colour of the yam cultivars after storage (Table 2). Although there were slight variations in colour, the scores were statistically similar. The *A. indica* and *O. gratissimum* agrobotanical treatments appeared to have significantly ( $P = 0.05$ ) altered the texture of the yam cultivar with score of 3.0 (slightly hard) while others had scores ranging from 2.1 to 2.5 (soft). The mealiness attribute of the tubers was the same except for *A. indica* treated tuber with score of 1.6 (slightly mealy). The GA<sub>3</sub> treatment on the average significantly ( $P = 0.05$ ) detracted from the sweetness of stored yam tubers, making the tubers almost taste bland.

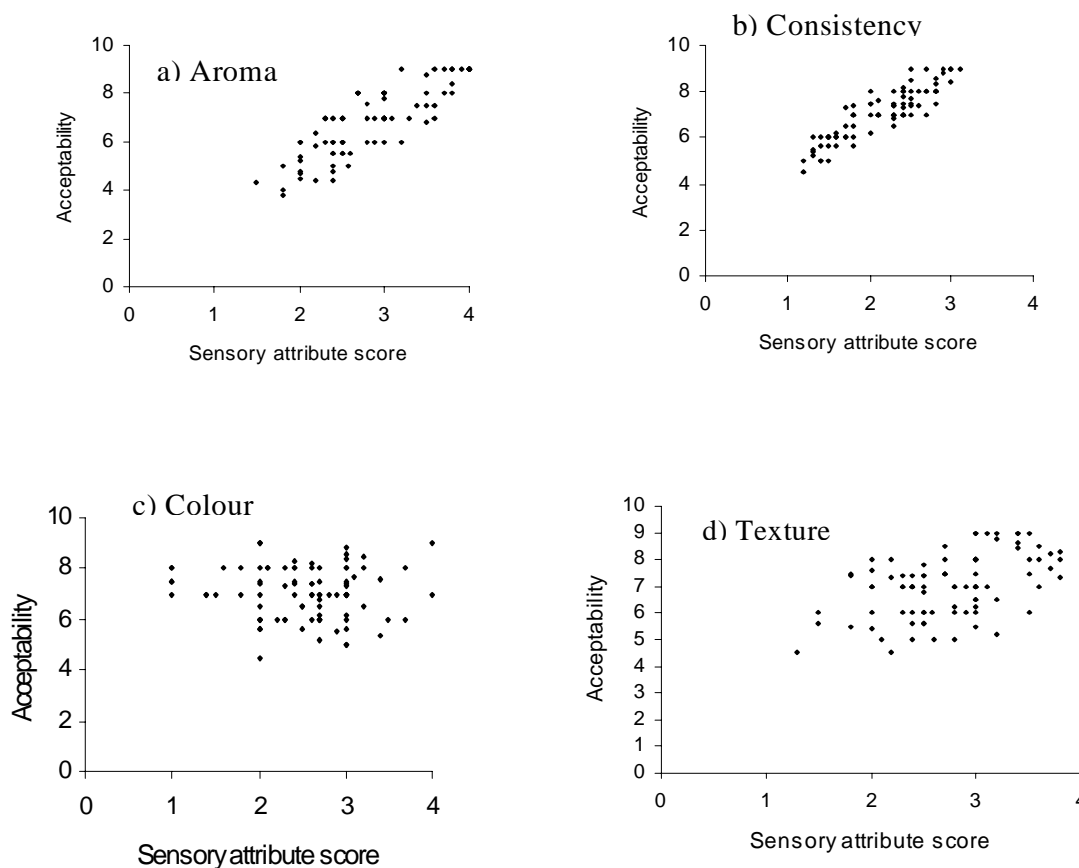
Based on subjective general acceptability scores, boiled yam from Danacha and Nwaopoko were significantly ( $P = 0.05$ ) most acceptable to the panelists with Pepa and Amula being the least accepted (Table 3). Although, *O. gratissimum* treatment appeared to give the most acceptable food yam, differences did not attain significant levels either on the average or within yam cultivars. Generally, acceptability did not differ significantly with various agrobotanical treatments or with GA<sub>3</sub> treatment within each yam cultivar, rather differences were among the yam cultivars with Danacha and Nwaopoko differing significantly ( $P = 0.05$ ) from others.

### **Predictors of acceptability**

Among the sensory variables, taste attribute accounted for 70% to the total variation of general acceptability of boiled yam food while texture contributed only 2% (Table 4). Colour and mealiness attributes did not contribute significantly to the model and were therefore discarded. However, their relationships with the consumers' preference and general acceptability of boiled yam food are shown in the scatter plots (Fig. 1). The result for pounded yam food followed a pattern similar to boiled yam even though both were tested on different quality attributes. Among the sensory qualities of pounded yam foods, consistency and aroma were the major factors. Consistency accounted for over 60% and aroma less than 2% to the variation of general acceptability of pounded yam (Table 5). Similarly, colour differences were recorded but they did not attain any significant level. Consistency and aroma were positively and significantly related to the general acceptability of pounded yam food while colour and texture bore little relationship (Fig. 2). Danacha and Nwaopoko cultivars maintained best in terms of consistency and aroma while Amula and Pepa scored least in these attributes.



**Figure 1: Relation of (a) taste, (b) texture, (c) colour and (d) mealiness attributes to general acceptability of boiled yam food**



**Figure 2: Relation of (a) aroma, (b) consistency, (c) colour and (d) texture attributes to general acceptability of pounded yam food**

## DISCUSSION

Foods differ in their characteristic attributes that influence consumers' judgement for quality. In the present study, all the cultivars were either cream or yellowish in colour as recorded by the panelists even though the five cultivars belong to the group of *Dioscorea rotundata* commonly called white yam. The colour differences could be due to inherent physiological characteristics of the various used in the study. However, cream and yellowish colours appealed to the panelist most since there was no score for white and brown in their assessment. DuBose *et al.* [15] reported that colour is a very important sensory attribute of most foods since it influences the consumers' first judgement and provides sensory information, which may interact with the gustatory olfactory and textural cues to determine the overall acceptability. Francis [16] also remarked that when the colour is unappealing, consumers are unlikely to be able to judge the flavour or texture as favourable.



Texture and mealiness varied significantly among the cultivars and contributed most to the overall quality and acceptability of food yam. Danacha and Nwaopoko cultivars had the best of these attributes in this study. Anzaldua-Morals and Boune [17] had earlier reported that texture and mealiness of potato were dependent on cultivar. Evidence in this study showed that the texture and mealiness of yam food are dependent on the cultivar. The importance of this study is that, out of the five cultivars studied, Danacha and Nwaopoko are best for yam food and are therefore, recommended for caterers, consumers and also useful to the plant breeders as well.

The taste attribute was either slightly sweet or bland with no bitter taste noticed. This is not surprising because only the central portion of the tubers were used for this evaluation while the head and tail regions were discarded to avoid polyphenols and glycoalkaloids which are associated with bitterness [18]. Again, this study suggests that any trace of bitter principle in the tuber got lost in the water during cooking.

Agrobotanical treatments did not affect the culinary quality of the stored yam tubers as no evidence of such treatment was noticed in the prepared yam foods. This result suggests that the constituent active ingredients imparted on the tubers during storage by the agrobotanicals were water-soluble and heat labile or that their shelf life was less than six months and therefore had no effects on the quality attributes of food yams. However, gibberrellic acid (GA<sub>3</sub>) differentiated itself from the agrobotanicals by making the food taste almost bland with low acceptability score. This also suggests that the GA<sub>3</sub> probably interfered with the biochemical changes such as hydrolysis of starch in the stored tubers which increase the glucose level that makes yam taste sweet after storage [18]. Similar sensory analysis carried out by Girardin *et al.* [8] showed that GA<sub>3</sub> helped keep *D. alata* fresh five months after storage. This could be due to the GA<sub>3</sub> capability of delaying sprouting in stored yams since it has been shown that most of the biochemical changes in stored yam occur during sprouting [19].

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**Table 1: Objective evaluation of quality attributes of boiled yam as influenced by yam cultivars**

Quality attributes	Cultivar					s.e.d
	Amula	Danach	Ezakuwukpolo	Nwaopoko	Pepa	
Colour	2.4	2.6	2.6	2.4	2.3	1.17
Texture	1.8	3.0	2.6	2.9	2.0	0.16
Mealiness	3.0	1.2	2.2	1.5	3.0	0.19
Taste	1.9	1.8	1.8	1.4	2.0	0.14

based on the mode score for each attribute on the scale

Colour: 1 = white, 2 = yellowish, 3 = cream, 4 = light brown

Texture: 1 = slightly soft, 2 = soft, 3 = slightly hard, 4 = hard

Mealiness: 1 = slightly mealy, 2 = mealy, 3 = very mealy, 4 = waxy

Taste: 1 = sweet, 2 = slightly sweet, 3 = bland, 4 = slightly bitter

**Table 2: Objective evaluation of quality attributes of boiled yam as influenced by the agrobotanical treatments**

Quality attributes	Agrobotanicals						s.e.d
	<i>A.indica</i>	<i>O. gratissimum</i>	<i>X. aethiopica</i>	<i>Z. officinale</i>	GA <sub>3</sub>	Control	
Colour	2.2	2.3	2.4	2.4	2.3	2.2	1.28
Texture	3.0	3.0	2.5	2.1	2.4	2.2	0.20
Mealiness	1.4	2.6	2.3	2.2	2.5	2.4	0.20
Taste	1.5	1.5	1.9	1.5	2.8	1.5	0.20

based on the mode score for each attribute on the scale

Colour: 1 = white, 2 = yellowish, 3 = cream, 4 = light brown

Texture: 1 = slightly soft, 2 = soft, 3 = slightly hard, 4 = hard

Mealiness: 1 = slightly mealy, 2 = mealy, 3 = very mealy, 4 = waxy

Taste: 1 = sweet, 2 = slightly sweet, 3 = bland, 4 = slightly bitter

**Table 3: Subjective evaluation of cultivar and agrobotanical treatment interaction on general acceptability of boiled yam**

Cultivar	Agrobotanicals						Mean
	Control	GA <sub>3</sub>	<i>A.indica</i>	<i>O. gratissimum</i>	<i>X. aethiopica</i>	<i>Z. officinale</i>	
Pepa	6.9	6.3	7.0	7.6	6.0	6.6	7.0
Ezakuwukpolo	6.6	7.5	6.3	7.7	6.1	6.9	7.0
Danacha	8.0	7.7	8.4	8.7	8.2	7.6	8.0
Nwaopoko	7.8	8.7	7.9	8.8	7.7	8.9	8.0
Amula	6.5	8.3	7.0	7.6	7.1	7.9	7.0
Mean	7.2	7.7	7.3	8.1	7.0	7.6	7.4

based on the scale of 1 – 9 where:

1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 dislike extremely,  
 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much  
 9 = like extremely.

- s. e.d for comparing 2 cultivar means = 0.40
- s. e.d for comparing 2 agrobotanical means = 0.60
- s. e.d for comparing 2 cultivar x agrobotanical means = 1.20

**Table 4: Regression of boiled yam quality attributes on general acceptability**

Quality attribute	Estimate	Standard error of estimates	R <sup>2</sup>	Partial R <sup>2</sup>
Intercept	0.6566	0.5655		
Taste	0.8194	0.1283	0.6975	0.6971***
Texture	0.4410	0.2003	0.0528	0.020**
Total				0.6991

\* Significant at P ≤ 0.05; \*\* Significant at P ≤ 0.01

**Table 5: Regression of pounded yam quality attributes on general acceptability**

Quality attribute	Estimate	Standard error of estimates	R <sup>2</sup>	Partial R <sup>2</sup>
Intercept	2.5081	0.2976	0.7871	
Taste	0.2247	0.1099	0.7718	0.0102*
Texture	1.8804	0.1135	0.1158	0.6713**
Total				0.6915

\* Significant at P ≤ 0.05; \*\* Significant at P ≤ 0.01

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